

AN INVESTIGATION OF SOME EFFECTS OF
PHYSICAL FITNESS ON PERFORMANCE

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THESIS

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An Investigation of Some Effects of
Physical Fitness on Performance

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ABSTRACT

The relationship between physical fitness and performance as determined by psychomotor response and psychological state was investigated in an experiment using two different physical fitness programs, a series of tests, and thirty-two subjects. The subjects were divided into three groups: two experimental groups, each participating in different exercise programs, and a non-exercising control group.

An indication of an improvement in physical fitness of the two experimental groups was matched by an indication of improvement in psychomotor response and a decrease in degree of anxiety, depression, and hostility. Of the exercising participants, ninety percent of them considered themselves in better physical and mental condition after the nine week program, and ninety-five percent of the exercising participants expressed a desire to continue with a physical fitness program.

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I. INTRODUCTION

Some authorities in the field of physical fitness have professed that physically fit individuals are more alert, less subject to illness, and generally more productive than unfit individuals. J. Wilmore has stated that in a ten week study of over 75 joggers he found the following: "In addition to the purely physical bodily changes, there were subjective reactions such as feeling better, sleeping better and actually requiring less sleep, and increased efficiency in terms of getting work done." Dr. Wilmore agreed that the next step in the analysis of the effects of physical fitness should be the evaluation of the change in performance as a result of physical fitness.¹

K. H. Cooper has conducted some widely reported experiments relating to physical fitness. He reported, as did Wilmore, that his subjects generally felt better and worked more efficiently. As one of the participants in Cooper's aerobics program stated [Cooper 1970]: "After eight weeks on the conditioning program, I feel younger, stronger, and more alive. And my problems - the ones that looked so big before - well, they haven't gone away. But somehow they look smaller."

In other research, the results of physical conditioning has been related to quantifiable changes in performance. A series of experiments

¹Wilmore, J., personal conversation with one of the authors at the Preventive Medicine Center, Palo Alto, Calif., November 24, 1970.

was devised to investigate the effect of a burst of violent exercise upon the performance of a skilled visual-motor control task [Hammerton and Tickner 1968]. Groups of subjects were trained to perform an acquisition task of (a) moderate difficulty and (b) great difficulty. It was found that, after a 400 second burst of activity at a rate of approximately 0.14 horsepower, subjects at an ordinary level of physical fitness showed no decrement on task (a) but a marked decrement on task (b). This situation could be related to a case where an aircraft crew is called to launch in a sudden emergency, and the crew members must proceed some distance at a rapid pace to reach the aircraft. Such an incidence would require bursts of violent activity and the effects of such activity could cause a serious degradation in the performance of skilled tasks.

The evidence regarding the effects of physical fitness on performance, however, is not yet conclusive. The purpose of this research was to obtain additional evidence by investigating the relationship between an individual's state of physical fitness and his psychomotor response and psychological state. Psychomotor response refers to muscular actions which ensue directly from a mental process. Here, psychological state refers to an individual's degree of anxiety, hostility, and depression.

Two different physical fitness training programs were used:

(1) Jogging, and (2) Bicycling. Both are aerobic type exercises. Aerobic exercise is the term used here to describe exercise that stimulates heart and lung activity for a time period sufficiently long to produce beneficial changes in the body [Cooper 1970]. Running, swimming, cycling, and

jogging are typical aerobic exercises while there are many others. They all have one thing in common: they make the body consume large amounts of oxygen by making it work hard. The usual objective of an aerobic exercise program is to increase the amount of oxygen that the body can process within a given time. It depends on the lungs, the heart, and the vascular system. Aerobic capacity reflects the condition of these vital organs. Aerobic capacity is considered by some authorities to be the best index of overall physical fitness [Cooper 1970].

In Cooper's experiments to determine physical fitness, exhaled air was collected through a one-way valve from test subjects who were running on a treadmill. This air was analyzed to determine the maximum rate at which oxygen was used by the subjects' bodies during their exhausting effort. This rate (measured in milliliters per kilogram of total body weight per minute) is a measure of an individual's aerobic capacity and in the remainder of this study will be referred to as Maximal Oxygen Uptake (MOU). Because of equipment limitations, a less accurate method for determining MOU than that described above was used in this study.

R. J. Shephard [Shephard 1966] commented that the performance of a specific task can frequently be improved by exercise which is general and unrelated to the task. It is also worthy of note that in his work, the pulse reading on a bicycle ergometer after five minutes of vigorous exercise was considered to be the best index of physical fitness. Because of this recommendation and its adaptability to this experiment, the five

minute pulse reading was used as the index of physical fitness from which to determine MOU.

II. EXPERIMENT

A. APPARATUS

In order to measure physical fitness and performance the following testing equipment was used:

1. Physical Fitness Testing Equipment

A stationary bicycle ergometer with the commercial name of "Lifecycle" was used to measure the subject's physical fitness and to act as a method of conditioning for one of the physical fitness programs. This ergometer, shown in Fig. 1, possessed an electronic system that had the capability of measuring the user's pulse rate in heart beats per minute, the crank revolutions per minute of the bicycle, and the energy expended by the user in calories per hour. The system also allowed the user to select a preprogrammed twelve minute variable load course which simulated hills, valleys, and level terrain. This simulation was controlled by preset variations in the brake resistance. The load level setting on the bike could also be changed so that the preprogrammed course could be varied in difficulty.

Pulse rate was measured by the heart rate meter on the ergometer. The heart rate meter used a sensor which consisted of an earclip with a miniature light bulb on one side of the earclip and a photocell on the other side. When the earclip was attached to the ear lobe, light passed through the ear lobe and the photocell sensed the changes in



Fig. 1

Electrically Operated
Variable Load Lifecycle
Ergometer

light transmission which occurred between each heartbeat. Each time the heart beat (systole), fresh blood, which is very red, passed into the ear lobe. During the heart resting period (diastole), oxygen was removed from the blood cells which gave the blood a slight blue color. This difference in color caused a change in the light transmitted by the ear lobe which enabled measurement of the pulse rate.

2. Psychomotor Response Testing Equipment

The psychomotor test devised by the experimenters utilized basically the same equipment as that which has been described elsewhere [Pooch 1967]. The following items were included in this equipment: a counter timer; an oscillator; a tape reader; a small three inch by two inch screen on which the numbers 1, 2, 3, and 4 were generated by the tape reader; and a console on which the subject responded by pushing

one of four buttons, each button corresponding to one of the four numbers presented. Pressing the button corresponding to the number presented extinguished that number from the screen. A picture of this equipment is shown in Figure 2.



Fig. 2

Psychomotor Testing Apparatus

B. EXPERIMENTAL SUBJECTS

Approximately 1200 circulars were distributed to students at the U. S. Naval Postgraduate School requesting volunteers for the experiment. From the 1200 contacted, approximately sixty students indicated that they would be willing to participate. These volunteers were then contacted and asked whether they desired to be placed in a bicycle riding program, a jogging program, or a non-exercising program. This latter group was used as a control group for the psychomotor and psychological

tests. The non-exercisers had to be willing to take approximately one hours worth of tests before and after the exercise program and also agree not to participate in any physical fitness program until the termination of the study.

1. Grouping

From the sixty volunteers for the program, thirty-two were actually selected to participate in the program. Some criteria for choosing the participants were:

- a. no recent participation in physical fitness programs,
- b. absence of any planned daily exercise,
- c. medical fitness,
- d. apparent enthusiasm for the program.

The first two criteria were chosen to increase the chance that a subject would improve his state of physical fitness. It was the desire of the experimenters to have individuals who were not in peak physical condition improve their condition and then measure certain psychomotor and psychological parameters in order to determine their relation, if any, to the improvement in physical fitness.

The third criterion was chosen to reduce the possibility of harm to a participant. As all of the participants had not previously engaged in exercise on a regular basis, this was of prime concern. All potential participants' medical records were reviewed by the Medical Staff at the Naval Auxiliary Landing Field in Monterey, California. Any subjects who were in questionable health personally consulted with a physician prior to participation in an exercise program.

Enthusiasm was chosen as a criterion in order to reduce the number of drop-outs. Because of time constraints and the extensive time allotted to testing each individual, it was felt only a maximum of thirty-five individuals could be accommodated in the program. Assuming that the potential drop-out was initially likely to be less enthusiastic about the program, it was hoped that, by using this criterion, the reduction in sample size due to drop-outs would be minimized.

The ages of the participants in the experiment varied from 24 to 33, with the average being approximately 28-1/2. This is probably slightly younger than the mean age of the students at the Naval Postgraduate School, most of whom are in the 27-35 year range.

From the thirty-two selectees, twelve were placed in the experimental group which exercised five days per week on the ergometer, twelve were placed in the experimental group which jogged five days per week, and eight were placed in the control group. One reason for establishing a control group was to determine if a learning effect existed with respect to the psychomotor and psychological tests.

C. DESCRIPTION OF PHYSICAL FITNESS PROGRAMS

Both the cycling and jogging programs were nine weeks in length. This was not considered the ideal length for either program, but because all participants were students, and at the end of the ninth week of the program these students had one week of final examinations and a two-week vacation, it was deemed necessary to condense the programs as the

subjects had little desire to participate in a physical fitness program during the examination week or during the subsequent two-week vacation. Ideally, a twelve to sixteen week program would be recommended. However, it was felt a nine-week program was preferable to twelve or sixteen weeks with a three-week layoff in the middle of the program.

The ergometer program was initially developed with the assistance of Per-Olof Astrand and Irma Astrand for Lifecycle, Inc., of Concord, California, and the jogging program was an accelerated modification of Kenneth Cooper's program [Cooper 1970]. Descriptions of both the ergometer program and the jogging program follow:

1. Ergometer Program

Participants rode the ergometer over the pre-programmed twelve minute course once every workday, five days per week. On the basis of medical advice subjects started at a load level at which they would not continually exceed a pulse rate of 160. As the subject became stronger at a particular level and could complete the twelve minute course without exceeding a pulse rate of 160, the load level was increased. Increasing the load level in this way allowed for maximum cardiovascular stimulation with a minimum potential for heart damage.

Ten load levels are available with the ergometer. These load levels are designated load level 10 through load level 100. As the load level increases, pedaling the ergometer becomes more difficult. The numerical increase in load level is proportional to the degree of difficulty in pedaling (i.e., two times as many foot-lbs. per minute input

to the ergometer are required to maintain 80 r.p.m. at load level 100 as at load level 50).

At various time intervals during the daily twelve minute exercise period, the subject recorded his pulse rate on pre-printed forms. These forms were maintained by the individual participant and collected weekly by the experimenters throughout the nine week program. In this manner, the experimenters could monitor the subject's progress and also insure the subject was, indeed, participating in the program on a daily basis.

During the course of the nine week program, three subjects dropped out. One left the school, a second stopped for medical reasons, and a third cited a heavy academic load. Thus, nine of the original twelve subjects completed the program.

2. Jogging Program

The jogging program also commenced with initially twelve participants. Two jogging courses were established on paths and roads on the grounds of the U. S. Naval Postgraduate School. The first course utilized was a 1.3 mile course and the second course utilized was a 2.0 mile course. Both courses were over relatively flat terrain. Stakes were placed in the ground at quarter-mile intervals along both courses.

Initially, during the first week, subjects jogged a quarter-mile and then walked a quarter-mile in order to get their bodies acclimated to exercise and to insure no occurrences of physical problems due to the over-vigorous exercise. Also, during the first week, the experimenters

accompanied the subjects around the course to acquaint the subjects with the course and to boost any sagging morale.

After the completion of the first week, the program accelerated at a faster pace. Objectives were established in the form of times to complete one of the courses, and the participants were encouraged to attempt to meet the objectives by the end of a prescribed week. All participants were able to meet these preset objectives and, in many cases, the participant was able to perform significantly better than the stated objective. The following is a table of the objectives, by week, that were established:

TABLE I -- JOGGING OBJECTIVES DURING NINE WEEK PROGRAM

<u>WEEK</u>	<u>OBJECTIVE</u>
1	Walk/Jog 1.3 mile course as desired. No time objective established.
2	1.3 miles in less than 13 minutes.
5	1.3 miles in less than 10.5 minutes.
6	2.0 miles in less than 18 minutes.
9	2.0 miles in less than 16 minutes.

Participants were encouraged to jog, at a minimum, four days per week. Upon completion of the daily exercise, the subject checked his name off on a roster and recorded his time and length of run. Subjects were not accompanied by the experimenters other than during the first week. The participants were, however, encouraged to accompany each other around the course in order to maintain each other's morale.

During the course of the nine-week program, two of the original twelve joggers dropped from the program. One dropout was due to medical reasons and the other stated that he felt that the jogging program and a heavy academic load were not compatible.

D. TESTING PROCEDURES

1. Psychomotor Response Test

As previously mentioned, the test utilized to measure psychomotor performance involved a screen on which the numbers 1, 2, 3, and 4 were generated and four buttons which corresponded to the four numbers.

The subject was seated at a table with only the console and screen in front of him. The subject placed the index and middle finger of his left hand on the two buttons on the left, and the index and middle finger of the right hand on the two buttons on the right. A number was presented on the screen every two seconds by the tape reader. These numbers had been originally obtained from a random number table and then placed on the tape used by the tape reader. The subject responded by pushing the button corresponding to the number on the screen in order to extinguish the number. The time the number was on the screen was measured, i. e., the time for the subject to respond correctly, and then cumulated. An assumption in the development of this test was that the subject would respond in less than two seconds to each number presented. This was necessary as after two seconds the subsequent number was

always presented. Observation by the experimenters confirmed the assumption; that is, it was a very rare occurrence when a subject took over one and one-half seconds to respond correctly. After every fifty numbers, the cumulative response time was recorded and the timer was reset to zero. A total of 750 numbers were presented to a subject during a test. The subject was given a practice run of approximately thirty-five numbers prior to starting the actual test.

The psychomotor response test described above measures the response time of the subject in making two bit decisions when his capacity for processing information is not exceeded. From information theory, one bit decisions are defined as the amount of information that one needs to make a decision between two equally likely alternatives. Two bits of information provides sufficient information to make a decision between four equally likely alternatives. The number of bits of information is determined by taking the log to the base 2 of the number of equally likely alternatives.

A test utilizing 750 numbers was selected by the experimenters as it was felt that if there was to be a decrease in performance due to mental fatigue it would occur prior to the presentation of more than 600 numbers, or about twenty minutes into the test. Thus, it was hoped, a decrement function would appear due to mental fatigue. That is, it was hoped that the subject's response time for each fifty numbers would increase as the test proceeded. It was the initial hypothesis of the experimenters that, if the subject was in better physical condition, his

response time would be more likely to remain constant. The psychomotor performance test was given to each subject in the ergometer, jogging, and control groups both before the physical conditioning program commenced and after completion of the program.

Unfortunately this test provided no precise manner in which to measure false alarms (responding to a number other than the number presented on the screen). Close observation of the subject's fingers by the experimenters, however, resulted in the subjective conclusion that false alarms occur infrequently but uniformly throughout the 750 numbers. Therefore, if false alarms occurred, this would be reflected by a corresponding increase in response time.

2. Psychological Testing

The psychological test utilized was the Multiple Affect Adjective Check List (Appendix A). Affect may be defined as the psychological aspects of emotion, or the emotional response which is assessed by means of verbal reports. Most psychological measures tend to evaluate affect as a trait rather than a state [Zuckerman 1965]. The MAACL, however, attempts to measure the state, as measuring the state specifies the time referent (e. g., now, last week).

The MAACL is a self-administered test which provides measures of three of the clinically relevant negative affects: anxiety, depression, and hostility. Two types of the test are available, the "today" form and the "general" form. In the "today" form the subject responds positively or negatively to a series of adjectives describing how he has felt today

only, and in the "general" form the subject responds to how he has felt in some specified time frame in the past. In this experiment, the subject was asked to respond to how he had felt during the past week.

Most words appearing on the check list were direct indicators of the affective state. The remaining words, however, had no relationship to the affective state. The process by which words were selected to appear on the check list is discussed fully by Zuckerman [Zuckerman 1960].

The scoring of the tests was based on the subject's response to certain words and lack of response to other words. These key words are shown in Appendix B, as well as the specific scoring procedures utilized.

The MAACL has not been investigated sufficiently to relate the raw scores obtained from the tests to a specific degree of clinical affect [Zuckerman 1965]. However, normative data has been collected on many groups. The data on the group most nearly approximating the male naval officers used in this experiment, that being male college students, is presented in the table below.

TABLE II -- DATA COLLECTED FROM
FORTY-FOUR MALE COLLEGE STUDENTS

<u>Mean Age</u>	<u>Mean Education</u>	<u>Anxiety</u>		<u>Depression</u>		<u>Hostility</u>	
		<u>Mean</u>	<u>S.D.</u>	<u>Mean</u>	<u>S.D.</u>	<u>Mean</u>	<u>S.D.</u>
19	13.4	6.9	3.3	14.7	7.4	8.5	4.0

For use in this experiment, the MAACL was given to all subjects both before the physical training program commenced and after its completion.

3. Physical Fitness Testing

The physical fitness test consisted of riding the ergometer for five minutes through a "test" course and reading the subject's pulse rate upon completion of the five minutes of exercise. Then, by taking the subject's weight in kilograms, load level of the ergometer, age, and pulse rate into account, a physical fitness index was established. This index was maximal oxygen uptake (MOU), a measure of the amount of oxygen the body uses during physical exercise and whose units are milliliters of oxygen per kilogram of total body weight per minute.

In his research, Cooper has developed the following fitness categories for male subjects 30 years of age, the subject's category being determined by his maximal oxygen uptake. These categories are shown in the following table.

TABLE III -- FITNESS CATEGORIZATION BY MOU

<u>Fitness Category</u>	<u>MOU(Ml/Kg/Min)</u>
Very Poor	less than 25.0
Poor	25.0 - 30.1
Fair	30.2 - 39.1
Good	39.2 - 48.0
Excellent	48.1 plus

The physical fitness test was administered to all subjects in the two experimental groups prior to commencement of the training program and after completion. A load level of sixty was used on the ergometer for most of the testing. In cases where the load level of sixty caused a sustained pulse rate over 160, a lesser load level was used.

III. RESULTS

The results of the experiment are presented through the use of five separate tables. There is a table of physical fitness test results expressed in terms of maximal oxygen uptake, psychomotor response test results in terms of mean cumulative response time, and the MAACL test results in terms of three test scores which relate to the degree of anxiety, depression, and hostility. In each table the following values appear: the mean value and the standard deviation before and after physical training of the quantity being investigated, the difference between these before and after means, the "t" value from a "t" test for significance between the before and after means, and the level of significance of the "t" value.

Results of the physical fitness test were only obtained from the bicycling and jogging groups since the control group did not participate in this phase of the testing. These results are shown in Table IV.

TABLE IV -- MOU'S OF EXPERIMENTAL GROUPS
BEFORE AND AFTER PHYSICAL TRAINING

<u>GROUP</u>	<u>N</u>	<u>BEFORE</u>		<u>AFTER</u>		<u>DIFF.</u> <u>IN</u> <u>MEAN</u>	<u>t</u>	<u>LEVEL</u> <u>OF</u> <u>SIG.</u>
		<u>MEAN</u> <u>MOU</u>	<u>S.D.</u>	<u>MEAN</u> <u>MOU</u>	<u>S.D.</u>			
Bicycle	9	32.00	3.93	38.44	4.81	+6.44	3.123	.004
Jogging	10	35.60	5.02	41.40	5.13	+5.80	2.547	.0102

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Jogging	10	35.60	5.02	41.40	5.13	+5.80	2.547	.0102

In evaluating the psychomotor response test, mean cumulative response time for fifty responses is the quantity investigated. Results are shown in TABLE V for the experimental and control groups.

TABLE V -- MEAN RESPONSE TIMES OF EXPERIMENTAL AND CONTROL GROUPS BEFORE AND AFTER PHYSICAL TRAINING

GROUP	N	BEFORE		AFTER		DIFF. IN MEAN	t	LEVEL OF SIG.
		MEAN RESPONSE		MEAN RESPONSE				
		TIME	S.D.	TIME	S.D.			
Bicycle	9	35.36	3.82	31.17	3.26	-4.19	.512	.010
Jogging	10	33.70	2.54	28.87	2.86	-4.83	.065	.0005
Control	8	32.90	2.11	30.05	2.82	-2.85	2.289	.018

The Multiple Affect Adjective Check List yielded three scores -- a score for the anxiety phase, the depression phase, and the hostility phase. The results of testing in these three phases is presented in TABLES VI, VII, and VIII for both the experimental and control groups. The mean scores listed are the means of the raw data scores utilizing the scoring system elaborated on in Appendix B. No attempt was made to equate the raw data scores to any percentile ratings or clinical evaluations.

TABLE VI -- ANXIETY PHASE OF MAACL FOR EXPERIMENTAL AND CONTROL GROUPS BEFORE AND AFTER PHYSICAL TRAINING

GROUP	N	<u>BEFORE</u>		<u>AFTER</u>		DIFF. IN MEANS	t	LEVEL OF SIG.
		MEAN		MEAN				
		ANXIETY SCORE	S.D.	ANXIETY SCORE	S.D.			
Bicycle	9	6.32	3.74	6.11	5.16	-.21	.101	>.10
Jogging	10	4.60	4.11	4.70	2.98	+.10	.018	>.10
Control	8	5.75	3.32	6.25	2.86	+.50	.955	>.10

TABLE VII -- DEPRESSION PHASE OF MAACL FOR EXPERIMENTAL AND CONTROL GROUPS BEFORE AND AFTER PHYSICAL TRAINING

GROUP	N	BEFORE		AFTER		DIFF. IN MEANS	t	LEVEL OF SIG.
		MEAN DEPRESS. SCORE	S.D.	MEAN DEPRESS. SCORE	S.D.			
Bicycle	9	11.44	5.91	10.11	5.71	-1.33	.481	>.10
Jogging	10	12.60	4.96	8.81	4.95	-3.59	.712	.05
Control	8	14.75	5.79	15.25	5.45	+ .5	.177	>.10

TABLE VIII -- HOSTILITY PHASE OF MAACL FOR EXPERIMENTAL AND CONTROL GROUPS BEFORE AND AFTER PHYSICAL TRAINING

GROUP	N	BEFORE		AFTER		DIFF. IN MEANS	t	LEVEL OF SIG.
		MEAN HOSTILITY SCORE	S.D.	MEAN HOSTILITY SCORE	S.D.			
Bicycle	9	10.33	3.81	9.78	5.39	-.55	.253	>.10
Jogging	10	10.00	4.72	10.40	4.64	+.40	.190	>.10
Control	8	11.75	3.69	11.88	2.41	+.13	.081	>.10

At the termination of the physical training program, the participants in the two experimental groups were asked to complete a questionnaire concerning their impressions of the program in which they had participated, and physical fitness in general. It was the purpose of this questionnaire to supplement the quantitative data collected by the psychological and psychomotor tests. A summary of the responses is presented below:

1. Of the nineteen subjects in the two experimental groups, seventeen stated they intended to continue in a vigorous exercise program, something they had not been doing prior to this experiment.

2. Eighteen participants commented that they "felt more physically fit".
3. Seven participants commented that they felt daily exercise had contributed to a "feeling of inner well-being".
4. Six participants commented that they felt that daily exercise had "increased their self-esteem".
5. Four participants commented that they felt that exercising daily had "improved their family relationships".
6. Two participants commented that they felt that daily exercise had "reduced their personal conflicts".

IV. DISCUSSION OF RESULTS

The statistical evidence of the effects of physical fitness was based on a brief period of physical exercise and on a small sample size and, hence, the results were not conclusive. However, the results were suggestive. Both the bicycle riders and the joggers appeared to improve their physical and mental condition. It was interesting to note that the bicycle ergometer exercise program seemed to be as effective a conditioning program as the jogging program. The fact that the bicycle riders achieved a greater average increase in physical fitness than did the joggers might be attributed to the fact that the bicycle riders were more conditioned to the bicycle ergometer at the time of the final testing.

The MOU indicator of physical fitness when compared with Cooper's physical fitness categories showed that all exercising participants increased their fitness category to at least the Fair category, and the majority of cases to the Good category.

With both experimental groups, the decrease in response time for the psychomotor response test was statistically significant. However, it must also be pointed out that the mean reaction times of the control group also decreased, although the change was not as statistically significant as for the experimental groups. This indicated that although the psychomotor response test and the interval between testing were designed to minimize any learning effect, such an effect might be present.

It was interesting to note that there was no consistent reaction time increase or decrease during the thirty minute psychomotor testing response period. Prior to commencing the study, it was theorized that an individual's reaction time for the first few groups of fifty numbers would be relatively high until he adjusted to the test. His response time for the next few groups of numbers would then decrease until he became bored or saturated with the task. At that time, it was felt that his reaction time would then start to increase for the remainder of the test. This, however, was not observed, and, as a result, the decision was made to use a single mean response time for fifty numbers in the statistical analysis.

It was felt by the experimenter's that the subjects employed were in a stress situation that was probably not uniform throughout the program, and if this were the case it could have led to some questionable results in the psychological tests utilized. That is, the subjects were initially tested, prior to starting the exercise program, early in the academic quarter, six to twelve weeks prior to having any midterm or final examinations. The final tests, after the completion of the exercise program, were conducted just prior to final examinations which is a time at which it might be expected that the subjects would be in a higher stress state due to academic pressures. With this in mind, it is interesting to note that, in all but two cases, the scores for the two experimental groups on the hostility, depression, and anxiety phases decreased, which indicated less hostility, less depression, and less anxiety, while

the control group scores increased in all cases. Although the experimenters do not feel these results were "statistically significant", they suggest that the exercising subjects were, relative to the non-exercisers, less anxious, less depressed, and less hostile after completion of the physical fitness program. A larger sample size would have been desirable in order to possibly have had a more conclusive result.

The decision to employ students 't' tests for the statistical analysis of the MOU's and mean response times was based on the assumption that the underlying populations were normally distributed. The prescribed testing procedures for the MAACL psychological test endorsed the use of 't' tests for statistical analysis. A plot of the MOU's on normal probability paper did not suggest that the MOU's were not normally distributed.

The experimenters were quite encouraged by the subjects' response to the entire program as evidenced by the subjective results gained from the questionnaire given to the subjects at the completion of the program. With two exceptions, all participants appeared to feel that a physical fitness program was worthwhile and that they themselves intended to pursue a vigorous physical fitness program in the future.

V. RECOMMENDATIONS

This study is considered to have important implications for the Navy. It is therefore recommended that this study be continued and expanded to include longer exercise programs, more accurate testing techniques, more subjects, and alternate exercise programs.

As mentioned above, the exercise programs should probably be between 12 and 16 weeks in length in order to yield statistically significant results. Initial and final testing should be conducted at the same time of the academic quarter or training environment so that individuals would be approximately under the same external pressures for both series of tests. The testing techniques could be improved, particularly in the case of the psychomotor response test where the minimum interval between the numbers presented to the subject was two seconds due to mechanical limitations in the tape reader. Since the responses to individual numbers averaged less than .65 sec, a time interval of one sec between numbers would put a greater demand on the subject and most probably produce more statistically significant results. With more sophisticated testing equipment it would be possible to record false alarms (incorrect responses) as well as correct responses.

Many exercise programs are currently available to someone seeking physical fitness. Only two programs were tested in this study due to the time available. An interesting exercise technique that might

be tested in the future is that used in the Exergeny program. The Exergeny is a spring tension device which requires very little space to use and is adaptable to numerous different exercises, the combined program providing exercise for many parts of the body in approximately 18 minutes per day.

APPENDIX A

The following is the Multiple Affect Adjective Check List given to all subjects in both the exercise and control groups before commencing and after completion of the physical fitness program: Below you will find words which describe different kinds of moods and feelings. Check the words which describe how you have felt during the past week, from _____ until now. Some of the words may sound alike, but we want you to check all the words that describe your feelings during the past week. Work rapidly.

- | | | |
|-----------------------|-----------------------|------------------------|
| 1. _____ active | 14. _____ awful | 27. _____ cooperative |
| 2. _____ adventurous | 15. _____ bashful | 28. _____ critical |
| 3. _____ affectionate | 16. _____ bitter | 29. _____ cross |
| 4. _____ afraid | 17. _____ blue | 30. _____ cruel |
| 5. _____ afitated | 18. _____ bored | 31. _____ daring |
| 6. _____ agreeable | 19. _____ calm | 32. _____ desperate |
| 7. _____ aggressive | 20. _____ cautious | 33. _____ destroyed |
| 8. _____ alive | 21. _____ cheerful | 34. _____ devoted |
| 9. _____ alone | 22. _____ clean | 35. _____ disagreeable |
| 10. _____ amiable | 23. _____ complaining | 36. _____ discontented |
| 11. _____ amused | 24. _____ contented | 37. _____ discouraged |
| 12. _____ angry | 25. _____ contrary | 38. _____ disgusted |
| 13. _____ annoyed | 26. _____ cool | 39. _____ displeased |

- | | | |
|------------------------|----------------------|----------------------|
| 40. _____ energetic | 64. _____ incensed | 88. _____ patient |
| 41. _____ enraged | 65. _____ indignant | 89. _____ peaceful |
| 42. _____ enthusiastic | 66. _____ inspired | 90. _____ pleased |
| 43. _____ fearful | 67. _____ interested | 91. _____ pleasant |
| 44. _____ fine | 68. _____ irritated | 92. _____ polite |
| 45. _____ fit | 69. _____ jealous | 93. _____ powerful |
| 46. _____ forlorn | 70. _____ joyful | 94. _____ quiet |
| 47. _____ frank | 71. _____ kindly | 95. _____ reckless |
| 48. _____ free | 72. _____ lonely | 96. _____ rejected |
| 49. _____ friendly | 73. _____ lost | 97. _____ rough |
| 50. _____ frightened | 74. _____ loving | 98. _____ sad |
| 51. _____ furious | 75. _____ low | 99. _____ safe |
| 52. _____ gay | 76. _____ lucky | 100. _____ satisfied |
| 53. _____ gentle | 77. _____ mad | 101. _____ secure |
| 54. _____ glad | 78. _____ mean | 102. _____ shaky |
| 55. _____ gloomy | 79. _____ meek | 103. _____ shy |
| 56. _____ good | 80. _____ merry | 104. _____ soothed |
| 57. _____ good-natured | 81. _____ mild | 105. _____ steady |
| 58. _____ grim | 82. _____ miserable | 106. _____ stubborn |
| 59. _____ happy | 83. _____ nervous | 107. _____ stormy |
| 60. _____ healthy | 84. _____ obliging | 108. _____ strong |
| 61. _____ hopeless | 85. _____ offended | 109. _____ suffering |
| 62. _____ hostile | 86. _____ outraged | 110. _____ sullen |
| 63. _____ impatient | 87. _____ panicky | 111. _____ sunk |

112. _____ sympathetic
113. _____ tame
114. _____ tender
115. _____ tense
116. _____ terrible
117. _____ terrified
118. _____ thoughtful
119. _____ timid
120. _____ tormented
121. _____ understanding
122. _____ unhappy
123. _____ unsociable
124. _____ upset
125. _____ vexed
126. _____ warm
127. _____ whole
128. _____ wild
129. _____ willful
130. _____ wilted
131. _____ worrying
132. _____ young

APPENDIX B

This Appendix describes the scoring and lists the key words utilized in the Multiple Affect Adjective Check List. The scoring of the tests was based on the subject's response to certain words and lack of response to other words. The words are placed in plus columns or minus columns. A subject's checking of a word in the plus column tends to indicate that he is in a state of anxiety, depression, or hostility, while checking a word in the minus column tends to indicate a lack of anxiety, depression, or hostility. These key words are shown below.

<u>Anxiety</u>		<u>Depression</u>	
<u>Plus</u>	<u>Minus</u>	<u>Plus</u>	<u>Minus</u>
afraid	calm	alone	active
desperate	cheerful	awful	alive
fearful	contented	blue	clean
frightened	happy	destroyed	enthusiastic
nervous	joyful	discouraged	fine
panicky	loving	forlorn	fit
shaky	pleasant	gloomy	free
tense	secure	hopeless	gay
terrified	steady	lonely	glad
upset	thoughtful	lost	good
worrying		low	healthy
		miserable	inspired
		rejected	interested
		sad	lucky
		suffering	merry
		sunk	peaceful
		terrible	safe
		tormented	strong
		unhappy	whole
		wilted	young

<u>Hostility</u>	
<u>Plus</u>	<u>Minus</u>
angry	agreeable
bitter	amiable
cruel	cooperative
disagreeable	friendly
discontented	good-natured
disgusted	kindly
enraged	polite
furious	sympathetic
irritated	tame
mad	tender
mean	understanding
offended	willful
outraged	warm
stormy	devoted
unsociable	
vexed	

To obtain the raw score for the test add the number of words not checked on the minus list to the number of words that are checked on the plus list.

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13. ABSTRACT

The relationship between physical fitness and performance, as determined by psychomotor response and psychological state was investigated in an experiment using two different physical fitness programs, a series of tests, and thirty-two subjects. The subjects were divided into three groups: two experimental groups, each participating in different exercise programs, and a non-exercising control group.

An indication of an improvement in physical fitness of the two experimental groups was matched by an indication of improvement in psychomotor response and a decrease in degree of anxiety, depression, and hostility. Of the exercising participants, ninety percent of them considered themselves in better physical and mental condition after the nine week program, and ninety-five percent of the exercising participants expressed a desire to continue with a physical fitness program.

KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
physical fitness						
psychomotor performance						
psychological state						
logging						
ergometer						
aerobic exercise						
Maximal Oxygen Uptake (MOU)						
Multiple Affect Adjective Check List (MAACL)						
exergeny						

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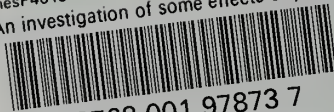
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